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PATENT SPECIFICATION

DRAWINGS ATTACHED

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Inventor:—THOMAS CARROLL HOVIOUS.

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COMPLETE SPECIFICATION

Fuel battery-rechargeable accumulator combination.

We, GENERAL ELECTRIC COMPANY, a corporation organized and existing under the laws of the State of New York, United States of America, residing at 1 River Road, Schenectady 5, New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a combination uniting a fuel battery and a rechargeable accumulator to efficiently supply variable electrical power requirements.

Batteries having anode and cathode reactants supplied from an external source continuously or on demand are termed fuel batteries. Such batteries have attracted a great deal of interest since they do not become discharged thereby requiring periodic recharge as in the case of secondary batteries or periodic replacement as in the case of primary batteries.

Fuel batteries may be sized to meet any desired power requirement. However, as an economic matter, fuel batteries incorporate significant amounts of expensive noble metals. Accordingly substantial economic penalties are incurred in sizing fuel batteries to meet transient or periodic peak loads which are much larger than the normal operating load.

It is a purpose of the present invention to provide an arrangement for efficiently meeting both the base and peak power requirements of an external electrical load.

It is an additional purpose of the invention to provide an arrangement for continuously supplying electricity to a unit having a low power requirement and periodically supplying electricity to another unit having a high power requirement.

The present invention provides the combination comprising

a fuel battery having positive and negative terminals,

a rechargeable accumulator having positive and negative terminals,

means connecting like terminals of the fuel battery and the accumulator to form an electrical circuit,

a low impedance biased switching means in said circuit, and

means shunting the accumulator terminals capable of imparting a high impedance to said switching means in response to a potential across the accumulator terminals in excess of a reference potential.

Suitably said rechargeable accumulator is a secondary battery, a secondary cell or a capacitor.

Suitably the combination of the present invention is constructed in such a way that

(i) the shunting means is comprised of actuator means capable of imparting a high impedance to said switching means, and a reference means having a low conductivity below the reference potential; or

(ii) the shunting means is comprised of actuator means capable of imparting a high impedance to said switching means, and a Zener diode having a Zener voltage corresponding to the reference potential; or

(iii) the shunting means is comprised of a solenoid capable of imparting a high impedance to said switching means, and a reference means having a low conductivity below the reference potential, and increased conductivity above the reference potential; or

(iv) the shunting means is comprised of an amplifier having an input and an output leg, actuator means connected to the output leg capable of imparting a high impedance to said switching means, and a reference means having a low conductivity below the reference potential and increased conductivity above the reference potential, said reference means being connected to the input leg.

The combination of the invention may

additionally include means tapping said fuel battery intermediate its terminals; furthermore, in addition to the last mentioned tapping means, there may be included an electrical device having base and peak power requirements, means electrically connecting said device to said tapping means and a terminal of said fuel battery, and means including a switch electrically connecting said device across the terminals of said rechargeable accumulator. Alternatively, the combination of the present invention may additionally include an electrical device having a low power requirement, an electrical device having a non-continuous, high power requirement, means connecting the low power requirement device across the terminals of said fuel battery, and means including a switch connecting the high power requirement device across the terminals of said accumulator.

The means connecting like terminals of the fuel battery and the accumulator in the combination of the invention may include means for limiting current flow which last mentioned means may be adjustable.

Our invention may be more fully understood by reference to the following detailed description read in conjunction with the accompanying diagrammatic drawings, in which

FIGURE 1 is a circuit diagram of one form of our apparatus, and

FIGURE 2 is a circuit diagram of an alternate form of our apparatus.

As herein used, the term "battery" designates a unit comprised of a plurality of cells. The term "fuel battery" designates a unit comprised of a plurality of series-connected fuel cells, and the term "secondary battery" designates a unit comprised of a plurality of rechargeable cells.

FIGURE 1 schematically illustrates an electrical circuit 100 including a fuel battery 101 and a rechargeable accumulator 102. Terminals 103 and 104 of the fuel battery and accumulator respectively are of like polarity and are jointed by a first conducting means 105. Terminals 106 and 107 of the fuel battery and accumulator respectively are similarly of like polarity and are joined by a second conductive means 108. A switching means 109 having a high impedance state and a low impedance state and being normally biased toward the low impedance state hereinafter referred to as low impedance biased switching means, forms a portion of the second conductive means.

A control unit 110 is connected to the first conductive means and the second conductive means between the switching means and the terminal 107. This unit is comprised of an actuator 111 connected in series relation with a reference element 112. As schematically illustrated by dashed line 111a, the actuator is associated with the switching means so that the latter may be selectively switched from its low impedance state to its high impedance state.

In order to illustrate the application of our inventive circuit, a third conducting means 113 is shown connected to the fuel battery mediate the terminals at tap 114. The first, second, and third conducting means are shown attached to connectors 115, 116, and 117 respectively. An electrical device 118 having variable power requirements is attached to connector 115 by lead 119 and to connector 117 by lead 120. Lead 121 electrically connects the device with connector 116 through a switch 122.

To illustrate the scope of our invention, FIGURE 2 shows an electrical circuit 200 comprised of a fuel battery 201 and a rechargeable accumulator 202. Terminals 203 and 204 of the fuel battery and accumulator respectively are of like polarity and are joined by a first conducting means 205. Terminals 206 and 207 of the fuel battery and accumulator respectively are similarly of like polarity and are joined by a second conductive means 208. A low impedance biased switching means 209 similar to switching means 109 forms a portion of the second conductive means. Also forming a part of the second conductive means is a current control device 225 capable of limiting current through the conducting means.

A control unit 210 is connected to the first conductive means and the second conductive means between the switching means and the terminal 207. This unit is comprised of an actuator 211, a reference element 212, and an amplifier 213. Dashed line 211a illustrates an operative association between the switching means and actuator so that the switching means can be switched from its low impedance state to its high impedance state.

To illustrate the application of the circuit of the present invention, a third conductive means 214 is shown connected to terminal 206 of the fuel battery. The first, second and third conductive means are attached to connectors 215, 216 and 217, respectively. An electrical device 218 having low power requirements is attached to connectors 215 and 217 by leads 219 and 220. An electrical device 221 having high power requirements is attached to connectors 215 and 216 through leads 222 and 223. Switch 224 is connected in series with the high power requirement device.

Our invention requires no elements which are in themselves new but rather relates to a new combination of conventional means. Our invention may be practiced with any fuel battery. In applications where it is desired to tap the battery mediate the terminals, this may be accomplished merely by

establishing electrical contact with an electrode, current collector, or other structural element lying at a potential intermediate that of the terminals. It is immaterial whether the battery is tapped at an anode or a cathode. The relationship of the potential difference between the terminals and the tap will depend on the number of cells separating each tap and the terminal. The number of cells employed and the position of the tap will vary, of course, depending on the particular voltage and power requirements of a specific application.

The rechargeable accumulators employed in the practice of the invention include known devices capable of storing an appreciable electrical charge and of delivering a direct current or pulse. Typical rechargeable accumulators include capacitors as well as secondary cells and batteries. Non-rechargeable accumulators such as primary cells or batteries are unsuitable for the practice of our invention.

The circuit controls may be chosen from a wide variety of conventional elements. Suitable reference elements include those having low conductivity below a predetermined or reference potential, and a markedly increased conductivity above the reference potential. Numerous reference elements of this type are well known and understood in the art including stabistors, such as Zener diodes; non-linear resistors; gas-filled reference tubes, such as neon and xenon tubes, etc. Zener diodes having a Zener voltage corresponding to the reference potential are generally most preferred. The low impedance biased switching means employed may take the form of any one of a variety of conventional switch arrangements. The actuator may be constructed integrally with the switching means or as a separate unit. For example, the switching means may take the form of a switch and the actuator the form of a solenoid acting against spring force, gravity, etc. to actuate the switch from its biased closed or low impedance state to an open or high impedance state. In another arrangement, switching means may be comprised of the spaced electrodes of an electron discharge device in which the actuator selectively controls a biasing grid operable to control conductivity between the electrodes. In still another arrangement, the actuator may be a separate unit connected to the switching means by an electrical circuit controlling actuation of the switch. The amplifier is preferably a semi-conductor device such as a transistor or tunnel diode although gas-filled and vacuum tube amplifiers may also be conveniently employed. The current control device may be a resistor, rheostat, base current regulator, of any other conventional current limiting control. Preferably the current control device is adjustable to various limiting currents.

To illustrate a specific use, a device 118 having base and peak power requirements is connected into the circuit shown in FIGURE 1. A fuel battery is employed having a potential difference between the terminal 103 and the tap 114 corresponding to the desired potential difference across device 118. A secondary battery 102 having a potential difference across terminals 104 and 107, corresponding to the potential difference between terminal 103 and tap 114, is placed in the circuit. The number of cells employed in the fuel battery is chosen so that the potential difference between terminals 103 and 106 will exceed the potential across terminals 104 and 107 by an amount sufficient to permit recharging of the secondary battery.

When the device 118 is operating at base power requirements, the low impedance biased switching means 109 and the switch 122 are open. Power is supplied to the device at a desired voltage from terminal 103 and tap 114 of the fuel battery. When peak power is required by the device, switch 122 is closed thereby allowing the device to receive power additionally from the secondary battery. When the peak power requirement is terminated, the switch 122 is opened and the fuel battery continues to supply the base power requirement.

If during supplying the peak power requirement the secondary battery has become substantially discharged, this will be detected by reference element 112. If the secondary battery is sufficiently discharged that the potential difference across the terminals 104 and 107 is below a predetermined or reference voltage, the conductivity of the reference element will decrease so that electrical current through the reference element and actuator 111 becomes negligible. With no current flowing, the actuator becomes inactive allowing switching means 109 to return to its normal, low impedance biased position. This closes the electrical circuit 108 joining the fuel battery and secondary battery. The fuel battery is then capable of recharging the secondary battery simultaneously with meeting the base power requirements of the device 118.

When the secondary battery has achieved a full charge, the potential difference across terminals 104 and 107 will again exceed the reference potential, and the reference element will show an increase in conductivity sufficient to allow passage of an appreciable current therethrough. This current causes the actuator to impart a high impedance to the switching means 109. The operating cycle of the apparatus is thus complete, and the apparatus ready to again meet peak power requirements.

Another specific application of our invention is described with reference to FIGURE 2. A device 218 having a low power requirement is placed in the combination shown along with a device 221 having a non-continuous high power requirement. Also, the device 221 may be one chosen to operate at a voltage substantially below that of device 218. A fuel battery 201 is chosen having a potential across terminals 203 and 206 corresponding to the potential difference desired across device 218. Similarly a rechargeable accumulator 202 is employed capable of developing a potential across terminals 204 and 207 corresponding to the potential required across device 221.

In operation, electrical power is supplied to device 218 by fuel battery 201. At this time switching means 209 and switch 224 are open and no power is being supplied to device 221. When it is desired to operate device 221, switch 224 is closed. The non-continuous high power requirement of device 221 is then supplied by rechargeable accumulator 202. When the power requirements of device 221 have been met, switch 224 is again opened. At this point reference element 212 exhibits a low conductivity in response to the decreased potential difference across terminals 204 and 207 of the accumulator. This prevents the passage of appreciable current through the amplifier 213 and essentially prevents current passage through the actuator 211. With the actuator 211 inactive, the low impedance biased switching means returns to the low impedance state and the circuit 208 is closed connecting the accumulator and fuel battery. This allows the accumulator to be recharged. The current control device 225 allows the accumulator to be recharged at any desired rate. Where a substantial time period between successive uses of the accumulator are anticipated, the charging current may be maintained at a low level, if desired. Such charging rate may be used with particular advantage on accumulators showing a tendency toward self-discharge upon standing. Alternately, the current control device may be chosen or selectively adjusted to permit rapid recharging of the accumulator. When the initial potential difference between terminals 204 and 207 is substantially restored, the conductivity of the reference element increases so that an appreciable current is passed through the amplifier and actuator. This allows the actuator to impart a high impedance to the switching means, and the cycle of operation is complete.

The foregoing description of our invention is merely intended to illustrate certain preferred embodiments. Numerous variations of a type obvious to a person skilled in the art may be undertaken with respect to the preferred embodiments without departing from the purview of our invention. For example, the control units 110 and 210 may be interchanged. The control unit 110 is shown to illustrate that the amplifier 213 is not a necessary element of the combination. In certain applications it may be desirable to utilize the actuator 111 as the only element of the control unit 110. Generally, however, it is preferred to use a reference element and an amplifier in combination with an actuator. Current control device 225 could be used in connector 108 equally as well as in connector 208. While the application of circuit 100 is described with particular reference to a secondary battery, it is appreciated that any rechargeable accumulator may be employed in the circuit. If the rechargeable accumulator 102 is a capacitor, it may be desirable to connect the conducting means 113 to the fuel battery terminal 106 rather than to the tap 114, since no appreciable over-voltage is required to charge a capacitor; such procedure would take advantage of the full potential of fuel battery 101, rather than only part of this value which is what would happen if connection 108 were attached to tap 114. In the event it is desired to operate device 221 at the same potential as device 218 and to use a secondary cell or battery as the accumulator 202, the connecting means 214 could be easily connected to a tap at the fuel battery rather than to terminal 206. It is appreciated that device 118 could be used with circuit 200 and circuit 100 used with devices 218 and 221. The connectors are, of course, useful when the circuitry to their left is packaged separately from the power requiring devices and circuitry to their right.

WHAT WE CLAIM IS:—

1. The combination comprising
a fuel battery having positive and negative terminals,
a rechargeable accumulator having positive and negative terminals,
means connecting like terminals of the fuel battery and the accumulator to form an electrical circuit,
a low impedance biased switching means in said circuit, and
means shunting the accumulator terminals capable of imparting a high impedance to said switching means in response to a potential across the accumulator terminals in excess of a reference potential.

2. The combination according to claim 1 in which the rechargeable accumulator is a secondary battery.

3. The combination according to claim 1 in which the rechargeable accumulator is a secondary cell.

4. The combination according to claim

1 in which the rechargeable accumulator is a capacitor.

5. The combination according to any one of claims 1 to 4 in which the shunting means is comprised of actuator means capable of imparting a high impedance to said switching means, and a reference means having a low conductivity below the reference potential.

6. The combination according to any one of claims 1 to 4 in which the shunting means is comprised of actuator means capable of imparting a high impedance to said switching means, and a Zener diode having a Zener voltage corresponding to the reference potential.

7. The combination according to any one of claims 1 to 4 in which the shunting means is comprised of a solenoid capable of imparting a high impedance to said switching means, and a reference means having a low conductivity below the reference potential, and increased conductivity above the reference potential.

8. The combination according to any one of claims 1 to 7 additionally including means tapping said fuel battery intermediate its terminals.

9. The combination according to any one of claims 1 to 7 additionally including

means tapping said fuel battery intermediate its terminals,

an electrical device having base and peak power requirements,

means electrically connecting said device to said tapping means and a terminal of said fuel battery, and

means including a switch electrically connecting said device across the terminals of said rechargeable accumulator.

10. The combination according to any one of claims 1 to 7 additionally including

an electrical device having a low power requirement,

an electrical device having a non-continuous, high power requirement.

means connecting the low power requirement device across the terminals of said fuel battery, and

means including a switch connecting the high power requirement device across the terminals of said accumulator.

11. The combination according to any one of claims 1 to 4 in which the shunting means is comprised of an amplifier having an input and an output leg, actuator means connected to the output leg capable of imparting a high impedance to said switching means, and a reference means having a low conductivity below the reference potential and increased conductivity above the reference potential, said reference means being connected to the input leg.

12. The combination according to any one of claims 1 to 11 in which the means connecting like terminals of the fuel battery and the accumulator includes means for limiting current flow.

13. The combination according to claim 12 in which the means for limiting current flow is adjustable.

14. A combination of apparatus constructed and arranged substantially as herein described and shown in the circuit diagram in Figure 1 or in Figure 2 of the accompanying diagrammatic drawings.

For the Applicants:—
G. H. MUNSTER & CO.,
Chartered Patent Agents,
Imperial Buildings,
56, Kingsway,
London, W.C.2.

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1,131,171 COMPLETE SPECIFICATION
1 SHEET
This drawing is a reproduction of the Original on a reduced scale.

Fig. 1.

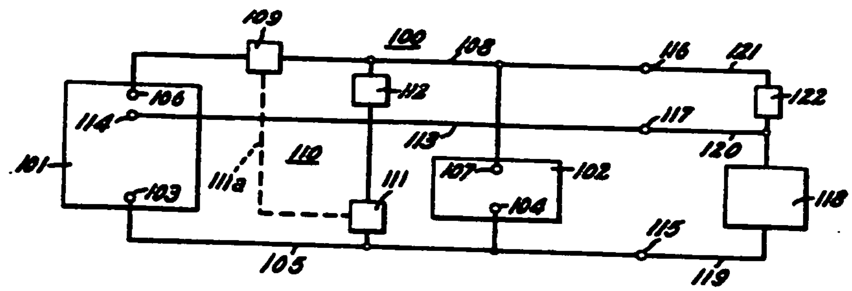

Fig. 2.